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BOOK REVIEW

Invertebrate Biology WILEY

New horizons in meiobenthos research

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This major work on meiobenthology has been co-edited by the venerable patriarch of the entire field: Prof. Olav Giere. It is not an introductory-level text, but rather particularly appropriate for graduate students and researchers whose work brings them into contact with this important group of organisms, either in their own right or as key players in the benthic ecosystem.

Although a book review should point out the weak points as well as the strong ones, I am at a loss to convincingly present any of the former. If pressed, I would simply say that one or two of the chapters by non-Anglophone authors are somewhat askance in the stylistic department. There, that's it. The rest is worthy of our highest commendation.

Chapter 1. Evolution of Bilateria from a meiofauna perspective—Miniaturization in the focus

Meiobenthology is a vast, relatively young field (from the viewpoint of weight of scientific effort), so of necessity, much of the work relates to and involves taxonomy and phylogeny at this stage. Typical of the effervescent state of animal phylogeny and taxonomy, this chapter focuses on the numerous contrasting theories and the approaches used or envisaged to settle the questions. It is indispensable as a contemporary starting point for future work in the field of meiofaunal evolution and may well hold important keys to the understanding of macrofaunal evolution.

Chapter 2. Meiofauna shaping biogeochemical processes

Again, this is a thorough treatment of the topic, with the same forward-looking perspective. Among the many gems: "The fact that certain meiofauna taxa can carry out nitrate respiration instead of oxic respiration is a fascinating topic" (p. 46). It certainly is!

The section on microplastic assimilation in meiofauna is of particular note, because here we are looking at the potential effects of microparticles on (mostly) very small metazoans, rather than on comparatively large ones, which are the main focus of prolific reports in the recent marine ecotoxicological literature.

Chapter 3. Meiofauna and biofilms—The slimy universe

This chapter is of particular interest for mudflat ecologists. It could have benefitted from better language editing and contrasts with the first two chapters in this regard. For example, I have no idea what an "empirical experiment" (p. 70) is!

Chapter 4. Meiofauna meets microbes—Chemosynthetic symbioses

This chapter delves deep into the fascinating and diverse phenomena of chemosymbioses. These symbioses are probably much more widespread among sediment-dwelling meiofauna than is currently known.

Chapter 5. Marine meiofauna diversity and biogeography—Paradigms and challenges

This chapter again necessarily relies on taxonomy but uses it to tackle more ecological questions of biodiversity. It contains the best explanation of alpha, beta, and gamma diversity I have ever seen; these concepts are usually poorly explained in other works.

The authors highlight the lack of reference libraries as a real obstacle to species identifications of larval-stage meiofauna, and we hope that within the next decade, the situation will have considerably improved. The writing is somewhat uneven; some sections are masterfully written, whereas others obviously struggle with the intricacies of English (few rules, many quirks), no doubt reflecting the contributions of the various authors. More appropriate proofreading would have helped here.

Chapter 6. Freshwater meiofauna—A biota with different rules?

This is a fascinating compare-and-contrast chapter. As might be expected, habitat fragmentation is a driving feature at the level of diversity. The authors also explore the functional aspects of freshwater meiofauna as ecological units and focus on carbon and energy transfers.

Chapter 7. Hidden players—Meiofauna mediate ecosystem effects of anthropogenic disturbances in the ocean

In this chapter, the authors literally leave no stone unturned, examining this topic from every pertinent viewpoint. The overall resilience of meiofauna is highlighted, which is somewhat of a relief in the midst of the prevalent gloom-and-doom forecasting.

Chapter 8. Deep-sea meiofauna—A world on its own or deeply connected?

The "deep sea" is obviously the least-studied biotope, especially with respect to meiofauna. However, as the authors so clearly state, "… the study of deep-sea meiofauna is not some esoteric pursuit focusing on organisms that are tiny, strange, difficult to study, and ecologically irrelevant. On the contrary, meiofauna are a dominant component of benthic ecosystems …" (p. 276), and they remind us that "Deep-sea benthic ecology really is just benthic ecology since the deep sea comprises over 98% of the oceans' depth range and most of the seabed surface" (p. 276). It is thus not surprising that much of this chapter deals with diversity and connectivity in what is by far the largest biotope on Earth.

Chapter 9. Polar meiofauna—Antipoles or parallels?

Again, the harsh conditions of the polar regions impose such severe challenges to meiofaunal research that it obviously lags behind that of the more accessible, clement biotopes. This chapter therefore highlights the baseline nature of this research, concerned mostly with numerical densities and the effects of environmental variables on these densities.

Chapter 10. Cave meiofauna—Models for ecology and evolution

It seems like sheer academic opulence to actually present an entire chapter devoted to "the often disregarded cave meiofauna" (p. 330), which is a further testament to the intellectual thoroughness of this book. Again, most of the material is diversity- or phylogeny-based, even more so than the other chapters, emphasizing the embryonic state of knowledge of this "niche within a niche" of zoology. In case you are wondering, Copepoda is the most diverse group found in the various types of caves.

Typical of this book, there are 12 pages of references in this chapter for 17 pages of text and figures. This gives an idea of the impressive breadth and depth of literature coverage.

I cannot but reproduce here a poignant, telling comment discovered within this chapter:

> Many species now regarded as cave-exclusive might just be waiting to be discovered in non-cave environments. These discoveries are more likely to happen in areas poorly investigated for meiofauna, i.e. most of the world … (pp. 340–341).

Yes, buried in this niche chapter is, to my mind, the most significant statement of the entire book, and indeed the entire field of meiobenthology: it is sorely understudied, and the authors of these chapters are nonetheless performing the Herculean task of pushing forward the frontiers of human knowledge in this underfunded, underappreciated, understaffed, yet immensely important domain. They are all to be commended for their service.

Chapter 11. Adapted to life at the limits

It seemed impossible to choose a best chapter from among the superlative works reported to this point, but this final chapter stole the show. Both the fascinating nature of the topic, as well as the precise prose, make this chapter a rare delight for any scientific reader. One example, when documenting anhydrobiosis in nematodes:

> In this drastic status of nondetectable metabolism, the animals, not alive and not dead either, can survive frost without the risk of freezing. Without any internal water present, nematodes have been found to survive for years (Lee, 2010; Wharton, 2002, 2004) and even for millennia (Shatilovich et al., 2018). (p. 377)

The account of anhydrobiosis in tardigrades is similarly captivating. This chapter on "the toughest animals on Earth" (p. 367) constitutes a marvelous finale to an amazingly broad and profound synthesis of the knowledge and promising future directions of research in meiobenthology.

I should mention two points that are part of the basic framework of the discipline, but which are not immediately obvious to biologists not yet familiar with meiobenthology. First, the breakthrough in quantity of meiofauna research from the start of the 21st century, alluded to at several points in the book, was in no small

measure due to the standardization of silica sol isopycnic extraction (Burgess, 2001). Very simply, much of contemporary and future research could not be performed without this efficient means of separating meiofauna from sediment.

Second, as underscored throughout this review, such is the yet-embryonic state of meiobenthological work that it is dominated by foundational research into taxonomic–phylogenetic diversity. Ecological investigations often focus on entire higher taxa, such as nematodes and copepods (equivalent to focusing ecological studies on, e.g., all arthropods or all chordates), while comparatively little is known about the physiology and ecology of lower taxonomic levels, much less individual species. Given the difficulty of such a task, and the very long road ahead to arrive at this point, I suspect we may wait many years before such knowledge becomes available.

Conclusion

This work does far more than present a higher level synthesis of the state of meiobenthological knowledge to date. True to its title, the volume consistently and almost fastidiously outlines the most promising directions and methodological advances for further research in this field: the "new horizons." Reading this book felt like assimilating the meiobenthology equivalent of the whole Library of Congress. Yet almost its entire, impressive content was brought into existence because the authors, as Newton and his predecessors so appropriately formulated, were "standing on the shoulders of giants" and chief among them Olav Giere himself. With the collaboration of Michaela Schratzberger, this illustrious patriarch has gifted the field of meiobenthology with its most important work to date.

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